THE AETHER STORY

According to Einstein it has no meaning to speak of motion relative to the aether. He likewise denies the existence of absolute simultaneity. It is certainly remarkable that these relativity concepts … have found such a rapid acceptance.

Hendrik Lorentz (1913)

Aether is everywhere.

Arthur Eddington (1934)

The formal content of special relativity is entirely coded in the Lorentz transformations, which were written by Lorentz, not by Einstein, and several years before 1905. What was Einstein's contribution? It was to understand the physical meaning of the Lorentz transformation.

Carlo Rovelli (1993)

Along with the exit of ether from the stage of physics, gone also was the notion of absolute motion through space. The Michelson-Morley experiment proves unequivocally that no such special frame of reference exists.

Tai Chow (2006)

It may be possible to have an underlying ("micro") time without running into the observationally excluded preferred frame.

Fotini Markopoulou (2007)

There's no way to avoid it. I am quibbling with Tai Chow on philosophic grounds. He's a noted author. He says nothing controversial about Michelson and Morley. He gives voice to the accepted view. But what they do in 1887 becomes a pivot point for physics. We need to understand it. Their experiment is meant to measure a change of light-speed in the Special Frame, or rather in the aether they and other physicists imagine it to be. It found no change. But it *didn't* prove there is no aether or no Special Frame.

The accepted view is too that their experiment led Einstein to relativity. Einstein begs to differ. He says he didn't notice what they did.

What does he do? Well, he remodels old ideas in a new and beautifully simple way. He transforms the measured speed of light into a fundamental property of space and time. In doing so he gives the kiss of death to aether as it was imagined in the 19th century. The accepted view is that he shows there is no Special Frame. He does not. It's true he *thinks* that physics should not need a Special

Frame. True too that SR doesn't need one—indeed this is its only innovation.

This might seem a slight accomplishment. But it resolves a rat's nest of conceptual untidiness that, before 1905, plagued physics and philosophy for years. After a short pause for digestion SR soon gets rave reviews. What Einstein says—or doesn't say—gets passed around at parties. But what he says will change when he digs into gravity.

What he does say in '05 is: The Special Frame's not needed. Not for what he's working on then anyway. Over time it turns into the bumper-sticker version: 'No Special Frame.'

It's made for outer space and science fiction. I ask Frank to imagine that his spaceship is in one of those vast voids of space. The nearest stars are a gazillion miles away. How can he tell if he is moving and, if so, which way?

Will he go along? He shuts his eyes; he makes some small show of acceptance. He can fire his rockets any way he wants. The view from his porthole doesn't change. He has no way to know how fast he's going or which way he's heading. So now we put a star in his *gedanken*-neighborhood. With perhaps a planet too, or nine. He knows how fast he's closing on them before I have time to say: Pluto *is* a planet. That is, he can measure his speed *relative* to a nearby object. His need for such an object is what 'no Special Frame' implies. Speed has no meaning without something to observe.

If he could find a Special Frame he wouldn't need those planets. More importantly for physics, a universe that has a Special Frame has absolute time. Everyone can set their clocks by it; they all agree. It sounds useful except Einstein says that he can do without it.

So what *does* SR say? Well, that depends which version. One might choose from three. They tend to be attributed to Einstein, who literally writes the book, to Minkowski, whom he inspires to invent Spacetime, and to Lorentz, whose work inspires them both. Einstein doesn't figure out the math (as Rovelli says; although it's not Lorentz it's Larmor). What *does* Einstein do? He sees a simpler way to get the same equations. It's more beautiful. It shows, he says, the meaning of the math.

The three (in sequence) might be roughly put this way:

Larmor/Lorentz	3 + 1 dimensions are real and there is a Special Frame
Einstein	4 dimensions may be real (ten years later, not really) and a Special Frame's not needed (but, ten years later, yes it is)
Minkowski	4 dimensions are real and there is no Special Frame

Lorentz doesn't fall for either of the latter versions. To him, time is real, it passes, and it is distinct from space. He sees time and space the way the average Joe sees them. He thinks simultaneous means something in the universe—

notwithstanding he can't measure it.

To him relativity's a framework that he wants to *understand*. And maybe does. If so his understanding's swept away in the deluge. Then Minkowski 4-space slams the door on his ideas. Yet Lorentz's version works at least as well as its competitors. In 2008, Craig revisits all three interpretations, though he has a theological agenda. He makes a strong case for Lorentz. He makes passing reference to a lecture Einstein gave in Leiden in 1920—a matter of 'a touch of humor.' For some reason I don't rush to look it up.

How does it come to pass that Einstein and Minkowski win the day? I find lots of reasons, none that satisfy. Lorentz's theory is less beautiful than Einstein's. It's not as neat and tidy as Spacetime. Einstein is sexy; soon a scientific superman. Aethers are way out of fashion once again. And physics is about to meet the media.

Whatever. A hundred years go by. The pendulum is swinging. Philosophers and even physicists are re-evaluating old ideas. It's back to the future—not the movie but a Special Frame and a new aether too.

I do my best to walk him through it. He's getting used to the idea that a theory must be interpreted. For our purposes Lorentz's seems the soundest of the three. It makes more sense. It avoids the problems that the others seem to have. Lorentz seems, somehow, to offer him a way to a beginning, a concept of a space and of a time in which he might find something. Does *he* see this? In truth *I'm* pushing it and he's pretending that he's following. I'm pushing it because it's where we're heading next. Minkowski will repackage time with space and call it Spacetime. I'm pretty sure we need to tear them back apart.

Is he confused? He should be. It's confusing.